

# **Factors Influencing Occurrence, Scale, Mobility, Runout, And Morphology of Mass Movements on the Continental Slope**

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## **LONG-TERM GOAL**

Achieve an improved understanding of the relationships between sedimentation, environment, and the morphology of continental slopes. This goal will be accomplished primarily through investigations within the northern California (Eel River) study area and incorporation of data from around the World. An underlying assumption of our work is that the occurrence and morphology of mass movement features on the continental slope depend upon a combination of characteristics, each of which varies over the region in a consistent manner. The various component of this project are part of a concerted effort between the geotechnical groups at the USGS and Laval University. Their activities are very much interwoven but, for administrative reasons, their respective budgets are allowed separately as are the ONR reports.

## **OBJECTIVES**

Identify factors that can be mapped regionally and that determine where and how slope failures occur; derive a basis for producing regional maps that indicate relative landslide susceptibility. Model shear strength development with depth and incorporate this model into continental slope stability, post-failure behavior, and bedform processes. Observe and model pore pressure development in continental slopes. Analyze the relationship between seismic intensity, sediment instability and slope processes.

## **APPROACH**

Our research focuses on the factors that lead to variations in the sedimentological and environmental conditions determining slope failure. We develop improved correlation between engineering classifications and strength factors. We relate compressibility, physico-chemical properties and strength to sediment microstructure, observed using SEM techniques. We simulate sediment accumulation in specially designed large cells. We measure sediment rheological properties in a viscometer. Geotechnical properties are related to sediment density state, obtained from detailed logs of downcore variability of sediment density and sound velocity. Using available bathymetry, we construct slope maps. Seismic shaking variations are evaluated probabilistically by seismologists. In situ pore pressures are determined by means of the Excalibur probe (AGC-Atlantic). These pressures can be generated if the sedimentation rate is particularly rapid, if there is charging by bubble-phase gas, or if earthquake shaking disrupts the sediment fabric and causes it to collapse with a resulting increase in the pressure of interstitial fluids. Driving stresses are balanced against strength variations in a geographic Information System (GIS) to obtain a regional estimate of relative slope stability.

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Key individuals, at Laval: Jacques Locat, Jean-Marie Konrad, Harold Christian, Éric Boulanger, Priscilla Desgagnés, Fancis Martin, and Frédéric Laurent: strength and compressibility measurements, SEM studies, rheology measurements, and simulation of sediment accumulation.; at the USGS: Homa Lee, Ken Israel, Pete Dartnell, and Greg Martz: physical property logs of sediment cores and relations between geotechnical and classification properties, algorithms relating sediment properties, environmental factors, and slope stability within the framework of a GIS.

## **WORK COMPLETED**

During an oceanographic cruise to the Eel Margin on the Wecoma, one leg was dedicated primarily to geotechnical objectives (July 16-24, 1998). A group of four scientists came from Laval to join the research team (Locat, Bélanger, Desgagnés and Martin) so as to run an onboard geotechnical testing laboratory in cooperation with IUGS group. For our project, we collected xx box cores and yy Lehigh cores (this equipment was rented from GSC-Atlantic, Halifax). All cores were logged at 1-cm resolution for density, sound velocity, and magnetic susceptibility. Most of the box cores were tested on board for intact and remoulded shear strength and water content. A total of zz sites were surveyed in situ by means of the Excalibur probe which enable measurement of the interstitial pore water down to a depth of 4 meters in the sediments and the collection of 2 gas samples. Further tests conducted at Laval included oedometer tests, SEDCON tests, simple shear tests, Atterberg's limits, grain size, mineralogy, microstructure and rheology. Most of these data are entered into a GIS to evaluate regional variations in sediment properties and environmental loads. Algorithms convert these data into estimates of slope stability. In carrying out the above mentioned work, we participated to one STRATAFORM meeting in Keystone (Colorado) and to one sub-group meeting in Minnesota under with G. Parker, dealing primarily with mud flow rheology and experimental, testing.

## **RESULTS**

Classic slope failure features on the Eel Margin are rare even though our methodology shows a high vulnerability to slope failure during seismic loading, indicating either that mass wasting on the Eel Margin takes unexpected forms or that mass wasting is less significant than would be expected. Studies of shear strength development show a bi-linear function, resulting from bioturbation. Rheological studies of Eel Margin sediment show a highly thixotropic material, represented by a pseudo-Bingham model.

## **IMPACT/APPLICATION**

Relationships developed in this project show the importance of sediment liquidity index and seabed density profiles in representing the behavior of marine sediment. These values can be used to predict regional slope stability and the rheological behavior of debris flows.

## **TRANSITIONS**

Geoacoustic properties are being used by mappers and acousticians to identify lithologies acoustically. Rheological properties are being used by modelers to represent debris flows. Landslide generation models are being used by landscape evolution modelers. Along these lines, a meeting was held at the University of Minnesota with G. Pasrker to interface our activities and research interest on debris flows.

## **RELATED PROJECTS**

Lee has developed a USGS project to investigate sediment and pollutant transport on the Los Angeles margin that uses techniques produced by STRATAFORM. Locat is investigating the behavior of a newly formed sediment layer acting as a natural cap over contaminated sediment in Canada. The development of this project benefited from approaches developed within STRATAFORM.

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